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November 21, 2019

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street SW
Washington DC 20554

Re: ET Docket No. 18-295, *Unlicensed Use of the 6 GHz Band*
GN Docket No. 17-183, *Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*
***Ex Parte* Communication**

Dear Ms. Dortch:

The Fixed Wireless Communications Coalition (FWCC) responds to an *ex parte* letter and slide deck from Apple Inc. *et al*. dated October 7, 2019,[1] and other filings.

A. BACKGROUND

RLAN proponents seek to deploy unlicensed Wi-Fi-type devices (RLANs) in the 6 GHz bands, projecting 958,062,017 units in operation.[2] Licensed in these bands are about 97,000 Fixed Service (FS) links. Most operate at 99.999% or 99.9999% reliability. Many carry safety-critical services.[3]

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1 Letter from Paul Margie as Counsel to Apple Inc., Broadcom Inc., Cisco Systems, Inc., and Hewlett Packard Enterprise, to Marlene Dortch, Secretary, FCC, and attachment (filed Oct. 7, 2019) (October 7 filing).

2 *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band January 2018*, *attached to* Letter from Paul Margie, Counsel to Apple Inc., *et al.*, to Marlene Dortch, Secretary, FCC, in GN Docket No. 17-183 at 12, Table 3-1 (filed Jan. 26, 2018).

3 These include coordinating railroad trains, balancing the electric grid, maintaining service in water utilities, controlling pressure and flow in oil and gas pipelines, and backhauling public safety first responders' mobile communications. Many of these users and their associations have filed with the Commission to express alarm about RLAN deployment.

The RLAN proponents propose to deploy RLANs with no Automatic Frequency Control (AFC) in the FS bands at power levels up to 30 dBm EIRP for indoor devices, and 14 dBm EIRP for outdoor devices.[4] These could make up the majority of all RLANs.[5] They would be able to transmit anywhere, anytime, on any 6 GHz frequency, without regard to the risk of harmful interference to FS receivers nearby.

The proposed power levels are unheard of for unlicensed devices in a band that carries licensed, critical services. Misleadingly, RLAN proponents call these "low power indoor" (LPI) and "very low power" (VPL) (outdoor) devices, but in fact these power levels are higher—by orders of magnitude—than any uncontrolled devices the Commission has ever permitted in a licensed band used for critical services. There is no precedent for this degree of potential interference.

The FWCC opposes non-AFC-controlled RLANs on the ground that some are statistically certain to cause harmful interference.[6] One RLAN proponent concedes that "interference events inevitably will occur for some fixed links."[7] Far from being rare "corner cases," these will be more commonplace that the proponents are willing to admit. AT&T found multiple instances of probable harmful interference after looking at just a few dozen links, out of the thousands it operates.[8]

The RLAN Group disagrees. It has filed multiple submissions in a continuing effort to show that uncontrolled RLANs will not cause harmful interference to the FS. We have pointed out numerous defects in their analyses.[9]

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4 Letter from Paul Margie, Counsel to Apple Inc., *et al.*, to Marlene Dortch, Secretary, FCC, attachment at 8 (filed April 26, 2019).

5 Letter from Alex Roytblat, Wi-Fi Alliance, to Marlene Dortch, Secretary, FCC at 2 (filed Oct. 16, 2019) (the proposed uncontrolled devices "are the majority of Wi-Fi use cases today").

6 *See, e.g.*, Letter from Donald J. Evans and Mitchell Lazarus, Counsel for the Fixed Wireless Communications Coalition, to Ms. Marlene H. Dortch, Secretary, FCC at 8-10 (filed Oct. 31, 2019) (FWCC October 31 Letter).

7 Letter from Bruce A. Olcott, counsel to the Boeing Company, to Marlene H. Dortch, Secretary, FCC at 3 (filed Nov. 1, 2019).

8 Letter from Michael P. Goggin, AT&T Services, Inc., to Ms. Marlene H. Dortch, Secretary, FCC at 3 (filed Nov. 12, 2019) (AT&T Letter).

9 *E.g.*, Letter from Donald J. Evans, Mitchell Lazarus, Seth L. Williams, Counsel for the Fixed Wireless Communications Coalition, to Ms. Marlene H. Dortch, Secretary, FCC and Attachment A (filed Aug. 22, 2019); Letter from Donald J. Evans and Mitchell Lazarus, Counsel for the Fixed Wireless Communications Coalition, to Ms. Marlene H. Dortch, Secretary, FCC (filed July 25, 2019).

B. Fade Margin

The RLAN proponent' showings all tacitly concede that RLANs will put energy into FS receivers. They argue this will not cause harmful interference in large part because the energy will be taken up by FS "fade margin": additional capacity built into an FS link to withstand atmospheric events that would otherwise reduce signal strength at the receiver.

We have repeatedly explained there is no excess fade margin to soak up RLAN interference. Fade margin is expensive. FS designers build in only the necessary minimum to achieve the link's rated reliability, taking into account the path length, required data throughput, climate, and other relevant factors, perhaps with a small safety allowance.

The RLAN proponents insist the FS engineers are wrong—all of them. They say virtually all FS links have far more fade margin than they actually need, and so can tolerate even strongly interfering RLAN signals. The slide deck attached to their October 7 filing purports to show that "extremely high fade margins used in FS link design" are sufficient to protect FS links against even unrealistic RLAN interference.[10]

Note that the RLAN proponents do not propose to re-analyze each individual FS link for excess fade margin. Rather, they hope to persuade the Commission that virtually every FS link was wrongly engineered from the start to have far more fade margin than it needs. The proponents then assert a right to encroach on the supposed excess—which does not exist.

Attachment A details some of the more serious errors in the RLAN proponents' attempt to reengineer links designed by others. It explains that some of the values needed to accurately determine the fade margin of a link are not available in public databases, and identifies a number of outright mistakes.

C. Adaptive Modulation

The RLAN analysis explicitly assumes all FS links have adaptive modulation and coding (ACM) capabilities,[11] in the mistaken belief that even severe interference into an adaptive modulation link will "only" slow the link and therefore be harmless.[12] We explained how that level of interference into a link with adaptive modulation not only slows, but completely stops, a subset of ongoing communications.[13] But the effects are far worse for most FS links, which do not use adaptive modulation. AT&T, a major FS user, told the Commission that the "overwhelming

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[10] October 7 filing attachment at 34.

[11] October 7 filing attachment at 13.

[12] Comments of Apple *et al.*, at 15 (filed Feb. 15, 2019).

[13] FWCC October 31 Letter at 11-12.

majority (~85%) of its FS links" use fixed modulation.[14] This makes AT&T typical of the band as a whole: about 75% of the links in the Lower 6 GHz band (5925-6425 MHz), and about 90% of the links in the Upper 6 GHz band (6525-6825 MHz), still use fixed modulation radios, not adaptive modulation.[15] At a high enough level of interference, the link simply fails.

CONCLUSION

The RLANs in question will have no AFC control. When they do cause harmful interference and disrupt critical, safety-related communications, there will be no way to turn them off. They will continue transmitting and interfering for years, until they eventually wear out.

For the Commission to authorize such devices would be profoundly harmful to the public interest.

Respectfully submitted,

Mitchell Lazarus

Donald J. Evans
Mitchell Lazarus
Counsel for the Fixed Wireless
Communications Coalition

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14 AT&T Letter at 9 (filed Nov. 12, 2019).

15 Data courtesy of Comsearch.

Attachment A

Response to RLAN Group Filing on Multipath Fading in ET Docket No. 18-295, dated October 3, 2019

by George Kizer

This responds to the slide deck titled " Multipath Fading," dated October 3, 2019, submitted as an attachment to a letter from Paul Margie as Counsel to Apple Inc., Broadcom Inc., Cisco Systems, Inc., and Hewlett Packard Enterprise, to Marlene Dortch, Secretary, FCC in ET Docket No. 18-295 and GN Docket No. 17-183 (filed Oct. 7, 2019).

Summary

The RLAN slide deck claims to show that “almost all [Fixed Service] links have far higher [margin] than they need to perform at the required level.”[1] The supposed consequence is that RLAN signals impinging on the Fixed Service (FS) receiver will not cause harmful interference.

This is wrong. FS links need all of their margin to maintain communications through atmospheric fades. Below we identify some of the major errors in the RLAN analysis.

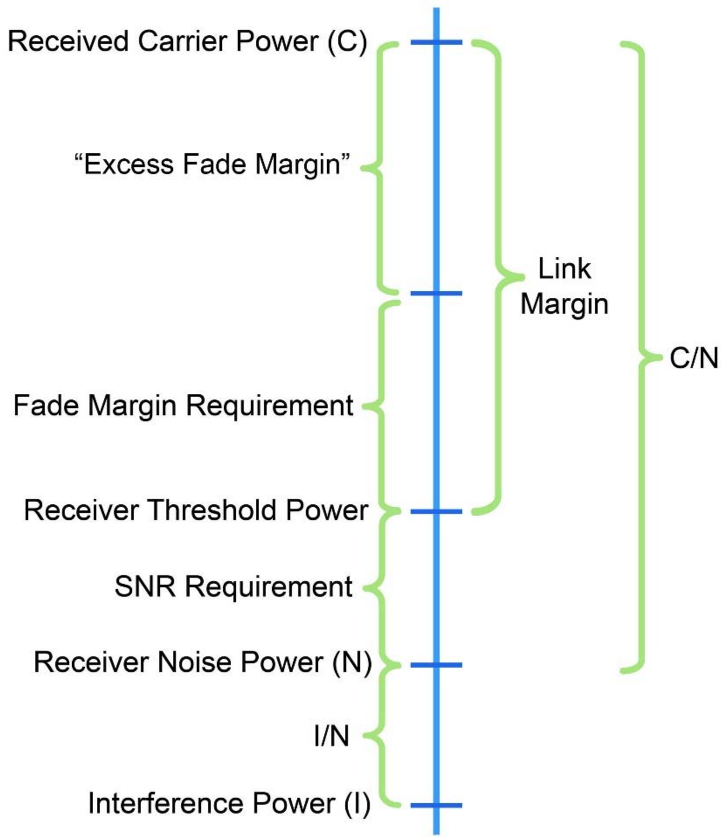
RLAN Slide Deck C/N Analysis

Beginning at slide 10, the RLAN slide deck attempts to utilize the concept of C/N (or C/[N+I]) to demonstrate that FS microwave paths have “excess” fade margin which could be taken up by RLAN interference without harming FS reliability.

Slide 13 tries to explain the C/N concept, but has several errors. On the diagram, the labels for “SNR Requirement” and “Excess Link Margin” are reversed. The label “Link Margin” is misplaced. The statement in the arrow on the right, “As Interference Increases C/N Decreases,” is incorrect. In fact, as interference increases, C/[N+I] or C/I decreases (and I/N increases).

Below is a corrected version of the diagram on slide 13, based on the points above—although there are still additional errors noted below.

[1] RLAN slide deck at 2.



Corrected diagram from RLAN slide 13

The unstated approach in the RLAN filing is to first estimate link ("fade") margin. Based upon an assumed path availability, the filing estimates the required fade margin using an assumed fade model, namely, ITU-R P.530—although engineers designing North American links usually prefer the Barnett-Vigants model as stipulated in ANSI/TIA Standard 10[2]. The filing then subtracted the "required" fade margin from the estimated link margin to arrive at a supposed "excess" link margin.

The approach must rely in large part on guesswork, as much of the required data is not in the FCC ULS data base. Let's walk through the steps.

To determine C/N, C and N must be estimated.

Received carrier power, C, is far end transmitter EIRP – free space loss + receive antenna gain – receiver waveguide loss – receiver coupling/filtering loss.

[2] ANSI/TIA-10-2019 Standard, *Interference Criteria for Microwave Systems*, 2019, Chapter 10 Path Fading: North American (NA) Path Performance Calculations, Vigants-Barnett Multipath Fading and Diversity Improvement Factors, pages 123 through 132.

Transmitter power is available from the FCC ULS database. Free space loss can be calculated. All the other factors must be estimated.

Next, receiver front end noise must be calculated using this equation[3]: N (dBm) = -114 + Noise Figure (dB) + 10 log (receiver bandwidth [MHz]). Since noise figure is not in the ULS database, it must be estimated.

The receiver threshold must be determined from the receiver's required Signal to Noise Ratio (SNR) for a given radio QAM mode.

Slide 14 of the RLAN filing lists receiver SNR values for various receivers QAMs. Their accuracy is doubtful, inasmuch as the 64 QAM values are less than those of 32 QAM; and values beyond 4 QAM should ascend approximately 3 dB for every QAM step.

A more trustworthy source for required SNR values is the ANSI/TIA 10 Standard, which lists default T/I values (rounded to the nearest dB) based upon thousands of coordinated radio records[4]. The co-channel T/I that represents an I/N of -6 dB causes a 10^{-6} Bit Error Ratio. The average receiver C/N for a 10^{-6} Bit Error Ratio would therefore be the average co-channel T/I value – 6 dB. We compare these values to the chart on RLAN filing slide 14:

Receiver Mode (QAM)	ANSI/TIA SNR Required (dB)	RLAN filing SNR Required (dB)	Difference (dB)
4	11	5.6-6.2	5.4-4.8
16	17	11.7-12.2	5.3-4.8
32	20	16.2-16.7	3.8-3.3
64	23	15.7-19.7	7.3-3.3
128	26	18.7-23.2	7.3-2.8
256	29	22.2-26.2	6.8-2.8
512	32	27.2-28.2	4.8-3.8
1024	35	30.2-31.2	4.8-3.8
2048	38	34.7-35.2	3.3-2.8
4096	41	-	-

Required SNR for Single Modulation Radios

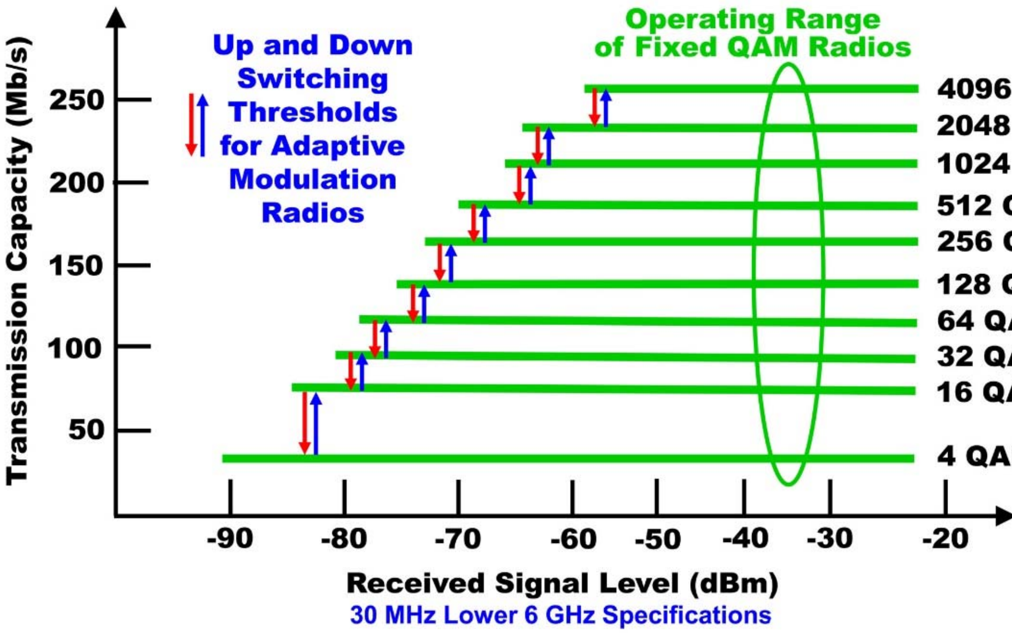
The RLAN filing Required SNR values are optimistic by 2.8 to 7.3 dB (4.5 dB average) when compared to industry averages.

When radios operate in adaptive modulation mode, the effective SNR for each QAM (except the lowest QAM) must be increased approximately 3 dB due to switching

[3] George Kizer, *Digital Microwave Communication* at 52 (Wiley 2013).

[4] ANSI/TIA-10-2019 Standard, *Interference Criteria for Microwave Systems*, 2019, Table 1 - (C-1) Typical Co-Channel Like Interference T/I Values, pages 57 and 58.

hysteresis[5]. (Note that due to FCC limitations[6] at 6 GHz, QAMs lower than 64 QAM require adaptive modulation.)



Thresholds for Fixed and Adaptive Modulation Radios

Taking into account the needed 3 dB increase in required SNR for adaptive modulation (for all QAMs except the lowest):

Receiver Mode (QAM)	SNR Required (dB)
4	11
16	20
32	23
64	26
128	29
256	32
512	35
1024	38
2048	41
4096	44

Required SNR for Adaptive Modulation Radios
(assuming lowest mode is 4 QAM and ANSI/TIA values)

Since the receiver threshold is not listed in the ULS database, it must be estimated. Receiver Threshold = Receiver Front End Noise (N) + Required SNR.

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[5] J. Zwiebel and G. Kizer, “Internet Protocol Microwave Radio Flat Fading Threshold and Dispersive Fade Margin Measurements”, *IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC 2013) Proceedings*, September 2013.

[6] 47 C.F.R. §§ 101.141(a)(3)(i), (ii).

Link ("Fade") Margin = Received Carrier Level (C) – Receiver Threshold (dBm)

Next, Required Link Margin must be estimated using an appropriate multipath fading estimation model (Barnett-Vigants or ITU-R P.530) and knowledge of the owner's operational requirements. The RLAN filing attempts to reengineer paths based upon unfounded assumptions. **This is the most serious failure of the RLAN approach. There is no way anyone else can know the link user's operational requirements, and how they relate to the radio path fade margin. This means any third-party estimate of path fade margin and "excess" fade margin is baseless.**

Errors in RLAN Filing Examples

Slide 18 claims a typical (50th percentile) FS microwave path has an estimated worst month availability of 99.9999% (six 9's) availability with an I/N of +20 dB. In fact, using Pathloss software and the Barnett-Vigants algorithm, the estimated path availability goes from essentially 100% without interference to less than 99.999%(five 9's) with interference—a serious loss of reliability. (This is a strange example for the RLAN proponents to choose since it is a 9-mile path, far shorter than typical 6 GHz paths.)

Slide 21 claims the 95th percentile 26-mile FS link will experience "slight degradation" by a 20 dB I/N. Again, using Pathloss software and the Barnett-Vigants algorithm, estimated path availability goes from 99.9999% without interference to 99.5% with interference—more than 7 minutes of failure per day, which renders the link useless.

Errors in RLAN Filing Generalizations

The RLAN filing's section titled "Correlation Between P_0 and C/N" section includes sweeping (and incorrect) generalizations. The filing states that FS designers counter multipath fading by employing spatial diversity antennas, employing frequency diversity, and ensuring large C/Ns.

Spatial diversity antennas

FS designers do use spatial diversity (two antenna on the same or nearby towers) to mitigate multipath fading, but diversity antennas can double the impact of RLAN interference.[7] Moreover, because a diversity antenna is often smaller than the main antenna, it has a broader antenna pattern that can receive interfering RLAN signals over a wider range of angles.

[7] *System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference*, Recommendation ITU-R F.758-6 at 8 (09/2015) ("The same degradation in fade margin will more impact systems with diversity reception resulting in about two times EP [error performance] degradation.")

Frequency diversity

Contrary to the RLAN filing, FS designers rarely use frequency diversity due to FCC rule §101.103(c): “Frequency diversity transmission will not be authorized in these services in the absence of a factual showing that the required communications cannot practically be achieved by other means.”

Large C/Ns

“Large” C/N is a relative term as C/N requirements vary greatly with radio mode (QAM):

Receiver Mode (QAM)	ANSI/TIA SNR Required (dB)	C/N for 30 dB Link (“Fade”) Margin	C/N for 40 dB Link (“Fade”) Margin
4	11	41	51
16	17	47	57
32	20	50	60
64	23	53	63
128	26	56	66
256	29	59	69
512	32	62	72
1024	35	65	75
2048	38	68	78
4096	41	71	81

Expected Single Mode Radio C/N Requirements

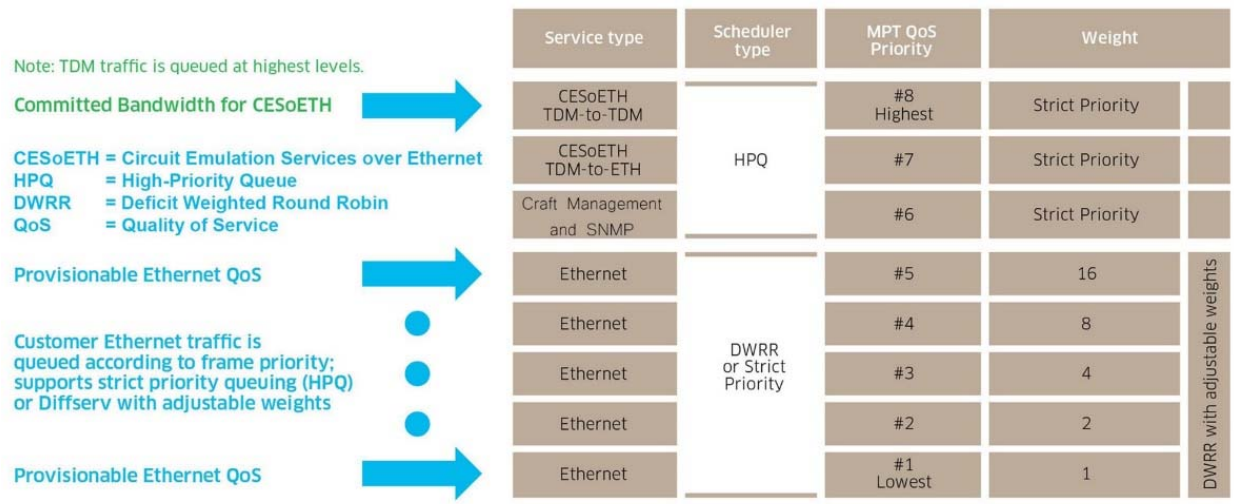
C/N requirements are 3 dB greater for adaptive modulation radios. Of course, C/N = Fade Margin + SNR.

Focusing on raw C/N values out of context can be misleading. RLAN Filing slides 26 and 27 suggest FS paths with C/N values between 49 and 75 are overdesigned—yet those are the expected values for operation between 4 and 4096 QAM with typically required fade margins.

Effects of Adaptive Modulation

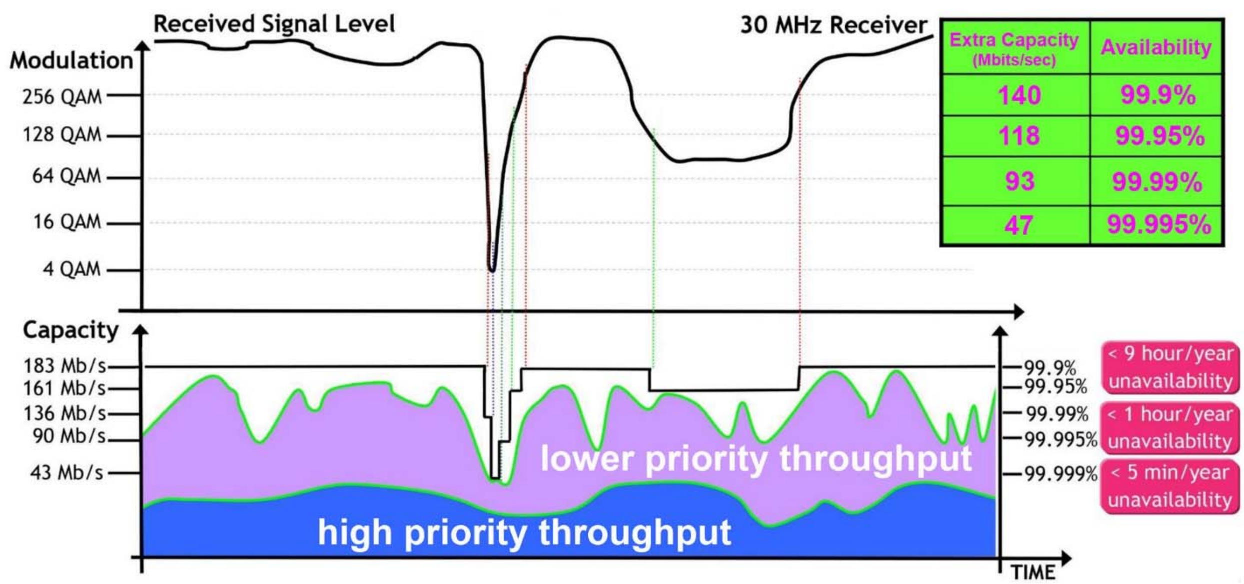
An FS link with adaptive modulation that has exhausted its fade margin, but encounters additional fading or interference, automatically downshifts to a slower but more robust modulation.

A common type of adaptive modulation radio transports many discrete data channels called VLANs. Those VLANS are assigned a priority using a standardized methodology.



Example of VLAN Quality of Service Settings

When the radio path fades or receives interference so the radio must downshift to a lower QAM to maintain communications, service does not merely slow down; some VLANs are completely lost.



During normal propagation conditions, the radio operates at high spectral efficiency (as high as 4096 QAM). When path conditions degrade *(e.g.*, during multipath fading and/or interference), the radio changes QAM mode to improve (decrease) the radio threshold (but at the cost of transmission capacity).

RLAN Filing slides 28, 29, and 30 analyze QPSK (equivalent to 4 QAM) path operation. They imply that since the QPSK (4 QAM) paths are operating at high availability, the path has not been impaired. In fact, when an adaptive modulation radio reverts to QPSK operation, most of the radio traffic has not been slowed down, but blocked. Far from being unimpaired, the link is unable to deliver a large fraction of its traffic. This is unacceptable.

Moreover, only a fraction of FS links use adaptive modulation. The rest operate at a fixed modulation.[8] For those, an intolerable level of interference simply shuts the link down.

RLAN Filing slides 31 and 32 claim a large majority of FS microwave paths operate at unnecessarily high availability. The claim is based on many questionable assumptions, including the required SNRs and recourse to the optimistic European ITU-R P.530 methodology, in place of the Barnett-Vigants model that is much more widely used in North America. It is not clear that these results represent reality.

Receiver Mode (QAM)	Fade Margin (dB)
4	56
16	48
32	44
64	42
128	38
256	36
512	33
1024	28
2048	26
4096	21

Example Fade Margin for Adaptive Modulation Radios
(nominal Received Signal Level = -35 dBm)

Regardless, the slides ignore the fade margin of higher QAMs which are considerably less that the relatively small QAMs considered – and dramatically impacted by "minor" harmful interference.

Conclusions

The RLAN filing concludes (at slide 24): "This study clearly demonstrates: …"

The filing does not clearly demonstrate anything. It implies that if one uses overly optimistic SNR values, can somehow accurately estimate receiver noise figure, transmitter and receiver coupling losses, and transmitter and receiver waveguide losses (all unavailable in the FCC ULS database), and relies on the optimistic European ITU-R P.530-17 estimation model (little used in North America), one may claim to have derived performance of FS radio paths. But the results rely heavily on guesswork. Every cumulative 10 dB in estimation errors in the previously mentioned parameters changes the estimated path availability a full order of magnitude.

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[8] Only about a quarter of the links in the Lower 6 GHz band and a tenth of the links in the Upper 6 GHz band use adaptive modulation. Data courtesy of Comsearch.

The statement, “[E]ven periods of extreme interference would only lead to a very short duration of throughput degradation ...”[9] is misleading, to say the least. “Throughput degradation” means the complete blockage of some VLAN data channels.

The statement "[m]any FS links operate at a power level exceeding what is necessary to maintain very high reliability”[10] depends on the flawed assumptions and interpretations we have noted above. In practice, FS links have only the power and margin needed to maintain their rated reliability through atmospheric fades, without much excess.

The conclusion of the filing is that “**most” FS paths** have adequate margin to sustain significant interference without incurring “**significant”** service interruption. This is factually incorrect. FS links are entitled to full protection against a significant potential for harmful interference.

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[9] RLAN slide deck at 34.

[10] RLAN slide deck at 34.